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PROPOSED EXPANDED CIVILIAN NUCLEAR POWER PROGRAM

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STATEMENT

This document is a committee memorandum prepared by the committee's staff and is not a committee report. It does not contain specific legislative recommendations, and is intended as a basis for further analysis and consideration by the members of the Joint Committee and the Congress.

FOREWORD

On November 21 and 22, 1957, the Joint Committee on Atomic Energy held seminars on atomic power with reactor designers and industrial representatives. Shortly thereafter, the Atomic Energy Commission held similar seminars. Both series of meetings brought out the need for clear-cut national objectives in our long-range nuclear power program.

On November 27, 1957, the Chairman of the Joint Committee sent a letter to Chairman Strauss of the Commission emphasizing the need for clarification of this country's policy objectives in the atomic-power field and urged close cooperation between the Joint Committee and the Commission in formulating a realistic and well-balanced program designed to carry out these objectives. In his reply of December 6, 1957, Mr. Strauss expressed willingness to review the AEC's nuclear-power objectives, policies, and programs, and to cooperate with the Joint Committee in furthering the United States position of world leadership in the field of nuclear power.

As a result of this exchange of letters a series of meetings was initiated between the Commission and the Joint Committee. To date there have been 4 meetings between the Commission and the committee and 12 additional meetings between the respective staffs. Concurrently, the AEC staff began preparation of a proposed plan for a long-range civilian nuclear-power program, while the Committee staff began revisions of the plan to reflect Committee views.

On June 4, 1958, the Atomic Energy Commission, in its testimony to the Subcommittee on Legislation of the Joint Committee on Atomic Energy released for publication a Statement on the Atomic Energy Commission's Civilian Power Reactor Program, dated June 3, 1958. At that time the chairman of the subcommittee, Mr. Holifield, stated that the Joint Committee would consider the Commission's statement as a tentative proposal until the Committee staff had completed an independent statement already under preparation.

All things considered, the AEC long-term program statement represented a genuine step forward and attempted to be responsive to suggestions by the Joint Committee. However, it did not cover completely several aspects of the program reflecting Committee views.

The proposed Expanded Civilian Nuclear Power Program is a third draft statement by the Joint Committee staff based on discussions with the AEC and informal advice from a representative panel of reactor and industrial experts. For this purpose the following representatives participated: Dr. Walter Zinn, president, General Nuclear Engineering Corp.; Dr. Henry de Wolf Smyth, chairman, board of scientific and engineering research, Princeton University; Dr. Chauncey Starr, president, American Nuclear Society and vice president, Atomics International; Mr. Titus LeClair, manager, research and development,

Commonwealth Edison Co.; and Mr. James Grahl, director, atomic energy service, American Public Power Association (alternate for Mr. Samuel B. Morris, chairman, atomic energy committee, American Public Power Association). Dr. Smyth kindly assisted the Committee staff in the actual preparation of the second and third drafts of the statement. The draft program, of course, does not necessarily conform with the views of the listed members of the Committee or of the panel.

It had been our hope, as expressed in the 202 statutory hearings, that the views of industry could be obtained on the proposed long term program statement. The Committee in its report on the fiscal year 1959 AEC authorization bill also had expressed the hope and belief that informal agreement could be reached with AEC on the program statement before adjournment of this session of Congress. Unfortunately delays in the submission of AEC authorization legislation, and numerous AEC personnel changes have precluded obtaining industrial review or having an opportunity to reach complete agreement with the Commission.

This draft statement is being issued in order to obtain the views of industry on the program and to facilitate informal discussions with AEC and industry before the 86th Congress convenes.

CARL T. DURHAM,
Chairman.

CLINTON P. ANDERSON,
Vice Chairman.

CONTENTS

	Page
Foreword	v
Summary	1
Introduction	3
General technical objectives	5
Technological program	6
Estimated costs	8
Organization and administration of program	9
Domestic nuclear-power program	9
A. Privately owned plants	10
B. Government-owned plants	11
C. Special arrangements	11
Assistance to projects in other countries	11
Other considerations	12
Conclusion	13
Appendix—Reactor projects	15
Table I—Power reactors for new undertakings	16
Table II—Status of power reactors underway or proposed	17

PROPOSED EXPANDED CIVILIAN NUCLEAR POWER PROGRAM

SUMMARY

The objectives of this program are to demonstrate economically competitive nuclear power in the United States by 1970 and in "high cost" free world nations by 1968. Achievement of these objectives is expected to fortify our worldwide position of leadership in the peaceful applications of atomic energy, particularly with regard to atomic power.

The United States Government considers the achievement of these objectives important, and recognizes the need for positive direction of a clear-cut program to make certain the objectives are reached.

The program statement analyzes the technical progress needed to achieve economic nuclear power and outlines procedures to reach this goal. The work required may be divided into two general categories: (1) increased research and development, and (2) programed design, construction, and improvement of diversified nuclear powerplants. Present plans call for design studies of the 21 plants listed in table I of the appendix, and construction of about half of the most promising designs evolved. While the total capacity of plants to be built in this country is expected to amount to about 1 million electrical kilowatts, the purpose of the program is to develop information and not power per se.

The following methods are described for accomplishment of the program. The AEC would continue to direct and finance the major portion of reactor research and development as it has in the past. The design and construction phase would be carried out through an expanded and modified power reactor demonstration program of privately owned "second generation" plants, and through Government construction, by contract with private industry and non-Federal power organizations, of advanced experimental prototype plants and of other desirable plants not otherwise proceeding. Provision is made for review of the adequacy of these arrangements and consideration of additional alternatives.

The program also provides for cooperation with friendly nations in their programs for construction of nuclear powerplants. The Atomic Energy Commission would participate in research and development of American types of reactors to be constructed by free-world nations and would provide other assistance in connection with fuel cycles. Under the program proposed by Euratom, for example, about 6 plants would be built with a total capacity of about 1 million electrical kilowatts. Information developed in foreign participation programs would be made available to all American industry.

29959—58——2

The long-range nuclear power program is intended to bridge the present gap between high cost first generation plants and economically competitive nuclear power which will supplement conventional fuels to meet expanding power requirements. As soon as economic feasibility has been established, normal business incentives would stimulate greater industrial financial participation and support activity. The ultimate goal of the entire program is to develop strictly commercial plants which would be economically competitive without financial assistance from the Government.

INTRODUCTION

On July 31, 1953, the Joint Congressional Committee on Atomic Energy requested the Atomic Energy Commission to establish objectives in the field of reactor development for the ensuing 5 years and to draft a program for reaching those objectives. The Commission agreed and with the approval of the Joint Committee on March 23, 1954, initiated a 5-year plan to develop experimental reactor types which at that time appeared desirable and feasible for civilian power. In January 1955, the Commission added a power demonstration program which invited private industry and other non-Government groups to take the responsibility for the funding and construction of nuclear powerplants, with research and development assistance by the AEC.

Considerable progress has been made in reactor technology under the joint efforts of government and industry during the past 4 years of concentrated effort. New experimental power reactors, such as the organic moderated reactor experiment have been added to the program. Research and development on materials, processes and advanced reactor concepts have been expanded. Cooperative industrial efforts have resulted in the initiation of construction of several different types of plants.

On the other hand, plans and projects for design and construction of prototype and full-scale power reactors have not been progressing as rapidly as desired due to difficult technical problems and unanticipated increases in costs. Instead of being able to go directly from a reactor experiment to full-scale demonstration of an economic power reactor, as some optimists had hoped, experience has shown that probably several generations of intermediate and full-scale reactors of a given type will be required before the economic value of a given reactor concept can be determined. These technical and financial problems in turn have had a significant effect on the rate of progress in the civilian power reactor program.

During the past 4 years, the international implications of civilian atomic power development have become more clear and urgent. Thus the need for United States leadership in the atoms-for-peace program has become more pressing in view of the great activity in atomic power by others abroad. A further consideration is the need for United States assistance in atomic power development to the energy-short nations of the free world through such agencies as Euratom and the International Atomic Energy Agency, as well as through direct bilateral agreements.

It therefore is appropriate, as the initial 5-year experimental program draws to an end, to establish a clear-cut statement of nuclear-power objectives, both national and international. It is essential that the Commission's program proceed in an orderly manner toward these objectives and that the public, as well as industry, be informed of the program plans of the Atomic Energy Commission.

It was in this context that the chairman of the Joint Committee on Atomic Energy in November 1957, requested the Atomic Energy Commission to cooperate in the development of long-range objectives of an expanded nuclear power program and in formulating a program to carry them out. The Commission accepted the invitation and this program statement is the result of collaborative effort between the Commission and the Joint Committee together with some review by reactor and industrial advisers.

The reevaluation and development of the objectives and plans have been done with particular awareness of the increasing importance of nuclear power to our friends abroad. Careful consideration has been given to the roles of Government and industry in the conduct of the program.

PROGRAM OBJECTIVES

The general considerations reviewed in the introduction can be crystallized into the following objectives for the atomic power program of the United States Government:

(*a*) Achieve and demonstrate in the United States nuclear power competitive in cost per kilowatt-hour by 1970.

(*b*) Achieve and demonstrate in high-cost free world nations nuclear power competitive in cost per kilowatt-hour by 1968.

(*c*) Fortify the position of leadership of the United States in the eyes of the world in the peaceful applications of atomic energy, particularly with regard to power.

The United States Government considers the objectives of this program of great importance from a national and international standpoint and intends to provide positive leadership to make certain the objectives are achieved in terms of practical results.

The United States has relatively abundant supplies of fossil fuels. However, even in the United States there is a clear need for development of a new source of energy to supplement present sources. Assessment of the timing of this need depends upon projections of energy requirements, estimates of relative costs, and judgment of the importance of conserving fossil fuels for special uses in the chemical, metallurgical and propulsion fields. It is to be noted, in this connection, that power requirements in the United States are expected roughly to double every 10 years for the next few decades.

The urgency of the overall civilian nuclear-power development program is dictated primarily by the need for the United States to maintain a position of technological leadership in the nuclear field and the need for providing help to our foreign friends in their efforts to achieve nuclear power in significant quantities as soon as possible. The shorter time schedule for achieving competitive power abroad, as compared with achieving it in the United States, is believed feasible because of the generally higher cost of conventional power abroad. In order to serve this particular objective adequately we may be required to include projects which otherwise might not be required. On the other hand, experience and results in pursuit of this objective will be of great benefit in achieving competitive power in the United States which is harder to reach because of the low level of domestic power costs. The combined program for attaining these first two objectives will accomplish the third objective of fortifying our world leadership in peaceful applications of atomic energy. This leadership is impor-

tant in fostering an increasingly close relationship with our foreign friends and allies on a much broader base than purely military cooperation.

General Technical Objectives

During the period since the 5-year experimental reactor program was established in 1954 the steps necessary to achieve economic nuclear power have become more evident. It has become apparent that the present high cost of nuclear power results both from the high capital costs of the plants and from the high cost of the fuel cycles. To reduce these costs and to develop long-range benefits, the following general technical objectives are established as a guide:

(*a*) *Cheaper components.*—In plants proven technically feasible, this will require design simplification and standardization of systems and of components, adoption of less stringent specifications, utilization of commercial fabrication techniques and elimination of technical elegance where not necessary for functionally adequate and safe components and systems. In unproven plants this goal is secondary to early operation.

(*b*) *Cheaper field assembly.*—This will require development of machine welding of pipes, standardization of joints and fittings, minimization of shielding and containment requirements and coordinated training of scheduling, installation, and testing teams by both management and labor organizations.

(*c*) *Better fuel elements.*—This will require increased operating lifetime and greater total burnup in fuel elements plus production engineered factory methods to reduce fabrication costs.

(*d*) *Higher temperature steam.*—Fuel element cladding and reactor plant structural materials and components are needed for high temperature operation to take advantage of efficient conversion of steam to electricity in modern high superheat turbogenerators. Particularly important is the development of nuclear superheating methods.

(*e*) *Cheaper reprocessing.*—This will require development of improved methods for separation and recovery of uranium, plutonium, and useful isotopes as well as pyrometallurgical methods to rejuvenate fuel.

(*f*) *Cheaper waste processing and disposal.*—While this problem is not as urgent as the ones described earlier, it must be solved before the large increase in nuclear-power capacity anticipated in the late 1960's can be considered practical. Every effort to utilize the radiation and fission products in economic and beneficial ways should be made. These uses may alleviate the disposal cost problem and reduce the chemical reprocessing costs.

(*g*) *Use of plutonium as fuel.*—This will require fabrication and testing of fuel elements containing plutonium in varying percentages. One important application is in "slightly enriched" cores where plutonium may serve as the enriching agent to natural uranium. Another likely area is in the highly enriched seed region of a zoned reactor core.

(*h*) *Use of natural uranium as a fuel.*—This will particularly require metallurgical development to permit operation at high temperature and high burnup of pure or nearly pure uranium metal.

(*i*) *Breeding.*—The purpose here is to extend the earth's long-range fuel supply by utilizing a much larger percentage of the relatively abundant fertile material instead of relying primarily on fissionable

U–235. Recycling methods are needed for thorium and U–233 as well as for U–238 and plutonium.

(*j*) *Realization of incidental benefits.*—As a means of reducing overall costs, the byproduct value of incidental isotope production, food irradiation, radiation chemical processing and space and process heating should be explored.

Some progress has been made along these lines by the work of the 5-year program. As usual in such research and development work, this progress has not been as great as had been hoped. In the Shippingport reactor both capital costs and fuel cycle costs are higher than anticipated in spite of large expenditures for research and development. Operating information which may lead to lower costs is just beginning to be developed and evaluated.

The experimental boiling water reactor at Argonne was the first of the 5-year program to be finished and has given very promising results. The sodium graphite reactor has encountered delays and has just come to full power. Information already acquired soon will be supplemented by operating data. The organic moderated reactor, a later addition to the program, has been operating for some time rather more successfully than anticipated. The homogeneous reactor at Oak Ridge has encountered technical difficulties which so far have prevented an evaluation of it as a step toward economic nuclear power. The second experimental fast breeder has been delayed and is still under construction. The liquid metal circulating fuel reactor experiment added to the program in 1956 is not yet under construction because of developmental problems.

General supporting research has been extensive but the problems have turned out to be difficult. Further improvement is still needed in metallurgy and chemical processing to assure a cheaper fuel cycle. Development of plutonium as a fuel is just beginning and requires an expanded effort. Use of uranium oxide as a fuel looks promising but must be demonstrated on a statistically significant basis.

While the work of the past 4 years in the whole field of reactor technology has dispelled the rosy optimism which existed in some quarters on 1954, it has delineated many of the problems clearly and has laid a solid foundation for future work.

Technological Program

To achieve the general goal of economic nuclear power 10 technical objectives have been outlined. Reviewing these objectives makes it clear that they involve basic research in metallurgy, chemistry and physics; development, engineering and testing; design and, in the last analysis, construction and operation of nuclear powerplants. All these activities need to be carried on simultaneously and interact with each other. However, it is convenient to divide them into two categories: (1) the basic research and development program, and (2) the design and construction of reactor experiments, experimental and industrial prototypes, and full-scale power reactors, together with research and development specifically associated with such design and construction.

As part of (1) the basic research and development program, an increased effort on the development and improvement of the fuel cycle would be established to be responsive to the needs of power reactors generally. This effort would have as its objective, increased efficiency

and lower costs, not only for the whole family of water and organic nuclear powerplants (including those with nuclear superheat of steam) but also for fuel cycles applicable to high temperature power reactors utilizing liquid metal and gas coolants. The program would embrace materials development, design, fabrication, and chemical reprocessing of fuel elements and whole reactor cores. The work would include use of both uranium and thorium source materials and of all fissionable materials—i. e., plutonium, uranium 235 and uranium 233. It is the intent that general fuel cycle development would be about doubled over the recent level of effort. The plutonium recycle program to develop the use of plutonium for enrichment of fuels in applicable cycles also would be expanded.

For such a program of fuel cycle development to be successful, it must be accompanied by provision of adequate facilities for irradiation and postirradiation examination of fuel elements. The Commission should be authorized to provide additional test reactors either by making contracts to take time in facilities built by private industry or by construction of special test reactors to be built and operated for the Commission under contract such as the ETR at NRTS. The contract authority for future service should stimulate the building of necessary facilities by private industrial service organizations. Maximum use also should be made of large-scale power reactors for irradiation of multiton lots of developmental fuel elements after prototype fuel elements have been tested satisfactorily in test reactors.

The second part of the technological program aimed at reaching the 10 general technical objectives consists of building reactors of various types and sizes. The goal of this design and construction program is primarily information and experience. Such information should make it possible to solve the major technical problems listed and thereby put the atomic-energy industry in this country in a position to design, build, and operate nuclear powerplants economically competitive with conventional sources of power; first, in other countries; ultimately, in this country. This is the overall objective of the program as stated at the beginning of this report.

Such a reactor program should begin with design studies and progress through detailed design to construction, with review at appropriate stages to evaluate the desirability of going through with construction. It would be anticipated, in a number of cases, design studies or detailed design and estimates would show the particular proposal under review was unlikely to lead to lower costs and therefore should be abandoned. Such flexibility is essential to the program.

The program should include successive generations of full-scale powerplants of types already in advanced state of development such as pressurized or boiling water reactors. It should include prototype reactors of cycles which already have been tested in principle by reactor experiments but where further testing is deemed necessary to establish desirability of the type for full-scale powerplants. While it appears economic power will be achieved earliest in large plants, construction of some small industrial plants is needed to develop prototypes for areas having limited power demands. Small plants also might be useful to test new components for well-known types of reactors. To develop new types of reactors, the program should include reactor experiments as it has in the past.

It is visualized that construction of prototype or developmental nuclear powerplants will be initiated on schedules consistent with technical feasibility. The number and type of projects initiated each year will be dependent upon the status of pertinent technology. It is expected that several projects will be initiated some years while none may be initiated in other years. It is recognized that ultimate success of the program must lead to strictly commercial plants which are justifiable without financial assistance from the Government.

The size of the power reactors built should be sufficient to prove the technology and to provide a sound step in progress toward economically competitive nuclear power. The selection of size should represent a balance between reducing cost and gaining knowledge for the particular reactor type at its particular state of development. Some of the power reactors built may be low capacity nuclear powerplants while others are expected to be capable of generating several hundreds of thousands of electrical kilowatts.

Nuclear powerplant technology developed in our military and merchant marine projects will be useful to the civilian program, particularly in the smaller plant sizes. Consistent with security laws, the Commission should review and promptly make available unclassified information from these projects to the civilian program. The Commission should continue to push its program for greater declassification of nuclear-power technology and for easier access of bona fide civilian technical personnel into military prototype facilities, laboratories and contractor's plants. Likewise, information developed abroad in conjunction with the foreign phase of the program should fully and promptly be fed back into the domestic effort. The systematic gleaning, evaluation and application of information from all these varied sources will be a major undertaking and will require close coordination by the Commission.

As pointed out, the object of this program is information, not power per se. Possibly in every case the power would be more expensive than power from conventional plants. Yet the production of power would be desirable to gain operating experience with the large plants and the sale of power would reduce the overall costs.

The scope of the expanded program as envisaged for consideration during the next 5 to 7 years covers a total of 21 reactors of diversified types, including 9 reactors of large size, 4 of intermediate size, 3 of small size, and 5 small reactor experiments, totaling a little over 2 million electrical kilowatts. The type, size and status of these reactors are given in table I of the appendix. It must be realized that some changes may be required in the types, sizes and schedules shown in table I. It further is expected only about half of these projects will prove technically and economically desirable for construction.

Estimated Costs

The Joint Committee has made a rough estimate of the costs for these reactor projects. Assuming the capacity of the plants to be constructed at about 1 million electrical kilowatts and the average cost at $500 per kilowatt, the construction effort would amount to about $500 million. The associated design and development cost for this program would total about $375 million of which $250 million would be attributable to plants constructed and $125 million to plants

designed but not constructed. The total cost of these projects would therefore amount to $875 million over a 5- to 7-year period. On a 7-year basis, this would average $125 million per year of which a considerable portion would not be borne by the Government. It is expected the base program of general reactor research and development, exclusive of laboratory support facilities, would continue at an average of between $125 million and $150 million per year.

It should be understood that the expanded program does not include reactors now under construction, or already implemented. Nor does it include reactors constructed by private industry not specified in the list of reactor types for the expanded program. Tables I and II of the appendix list, respectively, the new reactor projects contemplated for the expanded program and the reactors already underway or proposed.

The question of how this program should be carried out and how some of the costs might be carried by industry is considered in the next section of this report.

Organization and Administration of Program

Basic policy.—Since the United States Government considers the objectives of this program of great importance from a national and international standpoint, the Atomic Energy Commission must provide positive leadership to make certain the objectives are achieved in terms of practical results. The leadership to be provided by the AEC during the next 5 to 10 years should be accomplished in a variety of ways, including the following:

(*a*) Continuance of responsibility by AEC for the conduct of the base program of research and development through its national laboratories, industrial contractors, universities and nonprofit institutions.

(*b*) Assumption by AEC of positive direction of the reactor development program from the stage of feasibility studies of promising reactor concepts, through the necessary reactor experiments, up through the construction and operation of experimental prototype reactors. Large-scale demonstration plants also would be constructed if not otherwise provided by industry.

(*c*) Provision of positive direction by AEC of the power demonstration program by the selection by AEC of the reactors to be designed and constructed, and the setting of realistic dates for submission, approval, and negotiation of proposals for each project. In the event a satisfactory proposal is not received within the time limit specified in the invitation, or is not implemented within a reasonable time to be specified in the proposal, the AEC promptly would assume responsibility for construction of the project unless sufficient cause can be shown for the delay.

Domestic Nuclear Power Program

General.—Projects wholly financed by private enterprise should be encouraged to the fullest extent possible. It should be recognized, however, during this transition period probably not many such plants will be built. The framework for cooperating with industry in the design and construction of prototypes and full-scale nuclear powerplants is visualized as consisting principally of two parts. The first

may be described private construction and ownership of plants with certain research and development assistance by the Commission. The second would consist of AEC construction under contract and ownership of certain experimental prototype reactors and of other projects not otherwise constructed, with as much industrial participation as possible.

A. PRIVATELY OWNED PLANTS

This cooperative program would be a continuing extension of the power demonstration reactor program with certain modifications to improve its effectiveness and flexibility. It would be subject to annual authorization and specific review as provided under section 261 of the Atomic Energy Act, and authorization legislation thereunder. Principal modifications now being considered in the ground rules announced on January 7, 1957 (with the third invitation for nuclear-powerplant proposals) are as follows:

1. AEC would designate projects to be supported on a project-by-project basis, taking into account suggestions made by privately owned, publicly owned and cooperatively owned utilities; and by atomic power design and equipment companies, architect-engineers, and consultants. Invitations for proposals in addition to describing the project would establish a reasonable deadline for submission, consideration, and negotiation of proposals for the project.

2. The nuclear powerplants designated should be based upon reasonably well demonstrated technology and should not require extensive research and development work. The research and development assistance should be well defined and should be such that construction can be initiated within a reasonable time not to exceed 18 months after signing of a contract.

3. The proposals must include an obligation for construction of a power reactor, but the commitment to construct may recognize certain possible unexpected developments in the project, such that the parties may mutually agree that insistence on plant construction would be unreasonable.

4. The Commission would consider requests for research and development assistance under somewhat more flexible terms than previously. For example, effort on all phases of the fuel cycle would be permissive; also, it would be recognized that it may become desirable to expand or otherwise modify the scope of the research and development assistance based upon results as the project progresses. The Commission would consider requests for assistance of the following types in connection with this program:

(*a*) Waiver of established Commission charges for use of source and special nuclear materials.

(*b*) Loan of heavy water without charge.

(*c*) Performance in AEC laboratories without charge, or at less than full cost, of mutually agreed upon research and development.

(*d*) Research and development contracts under section 31 (a) of the Atomic Energy Act of 1954 in support of specifically described research and development work in connection with design, construction and operation of nuclear powerplants.

5. The AEC would assume responsibility for the reasonableless of cost estimates and completion dates. In the event a satisfactory proposal for a designated project is not received by the deadline date, or negotiations are not promptly completed, or the party declined to proceed with the project, the Commission would undertake responsibility for the completion of design and construction of the project if it were still deemed desirable.

B. GOVERNMENT-OWNED PLANTS

1. The second part of the framework for cooperating with industry would take the form of announcements of invitations for proposals to participate under AEC sponsorship, direction, and ownership (of the reactor portion of the project) in the development, design, construction, and operation of—

(*a*) Experimental prototype reactors.

(*b*) Other specific reactor projects which are deemed to be especially timely and desirable by the AEC but for which no reasonable proposal has been received.

2. Such projects would be constructed at (*a*) AEC sites with the electric power, if any, to be consumed in connection with site operations, (*b*) at sites of municipal, State, Federal, or co-op owned systems, with arrangements similar to the second round power demonstration program, (*c*) or at sites where power may be distributed to private companies consistent with section 44 of the Atomic Energy Act.

3. The projects constructed under subsections 1 and 2 of this section would be operated under contract with the Commission for a period of time deemed by the Commission to be advisable for research and development purposes, but not to exceed 10 years. Upon the expiration of such period, the AEC with respect to 2 (*b*) and (*c*) shall offer the reactor and its appurtenances for sale to the cooperating utility. With respect to 2 (*a*) and in the event no utility elects to purchase under 2 (*b*) and (*c*), AEC shall dismantle the reactor and appurtenances.

C. SPECIAL ARRANGEMENTS

In exceptional cases, the Commission may also request specific authorization for proceeding with projects not specifically identified by the Commission which are proposed by industry or by other non-Federal organizations and which are deemed desirable but may not satisfy established criteria for Commission assistance.

Assistance to Projects in Other Countries

Assistance to nuclear-power projects in other countries must depend upon their desire and willingness to build nuclear powerplants with the assistance of the United States. The following types of assistance are brought together as a package which the United States is prepared to offer to friendly nations:

(*a*) Availability of our technology and scientific knowledge relating to the production of nuclear power;

(*b*) The pledge to supply enriched uranium required to operate a given reactor over its amortizable life;

(*c*) Reasonable assurance of the availability at acceptable prices of services in connection with the fuel cycle, including fabrication of fuel elements and chemical reprocessing of same at stated prices until such services are available from other sources;

(*d*) Contracts to purchase plutonium produced in reactors abroad for a reasonable period;

(*e*) Sale on the installment plan as well as the sale outright of enriched fuel inventory and, in appropriate cases, the lease of such inventory;

(*f*) Capital loans for foreign nuclear power installations through the Export-Import Bank under the same terms and conditions as such loans have been made to finance conventional power installations;

(*g*) Continuation and, if necessary, expansion of our facilities for training foreign technicians without which reactors cannot be operated;

(*h*) Some means for solving the problem of third-party liability which might accrue to American manufacturers on account of installations abroad. The Commission recognizes that the responsibility for solving this problem rests with the individual nations concerned, but that they should be urged to bring this problem to early resolution;

(*i*) A firm declaration of our intention to support, over an indefinite period, an expanded fuel cycle development program to improve performance of reactors to be built abroad with assistance from the United States. Such support would be given to manufacturers in the United States who would sell fuel elements abroad but might also be given to foreign manufacturers. In the latter case, the technology developed with United States assistance would be made available to all United States manufacturers.

The Commission is developing a cooperative program for specific application to Euratom and the six countries of Western Europe involved therein. Such a program, if timed properly, can be of great assistance to the development of economically competitive nuclear power in the United States. Moreover, cooperative programs with the United Kingdom and with other free-world nations are expected to be implemented through the IAEA or through direct bilateral agreements.

Other Considerations Affecting Domestic and Foreign Atomic Power Programs

It is possible that the amounts and types of assistance specified in the domestic and foreign atomic-power programs described in this report still may not be adequate to insure meeting the objectives of the program. If this is determined to be the case, consideration should be given to other methods of assistance, particularly in relation to the domestic program. This might include consideration of grants of financial assistance on an equitable basis to private utilities to pay for a portion of the difference between the estimated cost of a nuclear plant and a conventional plant, and an extension of the second-round program for cooperative and publicly owned systems. Consideration might also be given to Shippingport-type arrangements whereby the Government constructs and owns the reactor and the utility provides the turbogenerating facilities. Any such types of assistance would involve consideration of revisions of sections 44 and 169 of the Atomic Energy Act of 1954.

Conclusion

The first part of this paper reviewed briefly the history of civilian nuclear power in this country and the reasons for continuing a vigorous program. The remainder of the paper outlined a program for the development of nuclear power within the next 5 to 7 years. The program described is intended to be vigorous without being extravagant. The timing of successive steps is meant to be dictated primarily by technical progress. The estimated cost is relatively small compared to other Government expenditures.

Since President Eisenhower's speech before the United Nations on atoms for peace in December 1953, it has been an avowed Government policy to develop and make available to the free world the possible peaceful uses of the atom. Power from nuclear fission is one of the most obvious objectives of such a policy. It is essential that the Government of the United States fully implement the atoms-for-peace policy by providing positive direction and assistance to the civilian nuclear power program both at home and abroad. By taking this action the United States will retain its leadership in this field and will make a significant contribution to the development of economic nuclear power throughout the world.

APPENDIX

Reactor Projects

The program in pursuit of the stated objectives must continue to provide for the exploration of a considerable number of reactor concepts for the purpose of determining which one or ones hold the most promise for economic nuclear power and are, at the same time, reliable and safe. It is also recognized that the program must include the building of a number of experimental reactors, including several generations of nuclear powerplants of the same type but of successively improved designs. The success of the program will depend upon continuing a broad base effort of research and development and upon providing reasonable assurance that the number of plants built during the next 5 to 7 years will be adequate to reach the program's objectives. The selection of experimental or prototype nuclear powerplant projects will be based upon (*a*) having sufficient technology to proceed, and (*b*) judgment that the reactor type represented has sufficient economic promise to be capable of meeting the program objectives.

It should be recognized that specific projections of desirable projects within the program become less firm as time is extended. Program flexibility is essential in order to permit adjustments based on technological advances. The program must be subject to constant review to make certain new concepts are evaluated rapidly and projects proved not feasible are weeded out.

Table I lists, in rough chronological order, new reactor projects to be developed and studied during the next 5 to 7 years. It is expected information gained during the development and design stage will indicate only about half of these projects will show enough technical and economic potential to warrant construction. It is further expected that the reactor sizes and schedules may require modification and other types of reactors may be added to the list. Second generation reactors are scheduled so design and construction experience in the first generation reactor can be applied to the design of the second. Operating experience concerning high fuel burnup tests, maintenance and high plant factor reliability normally will not be available in time for the next succeeding generation, but considerable testing and startup experience should be available and usable.

Table II lists reactors now underway or already proposed.

As part of the expanded program, the AEC will coordinate efforts to derive incidental benefits from power reactors. Examples of such byproduct benefits include the use of expended fuel elements as irradiation sources (such as for food preservation) and the economic withdrawal of useful isotopes during chemical reprocessing.

TABLE I.—*Power reactors for new undertakings*

Project	Approximate electrical rating (megawatts)	Status	Approximate time interval for project
Heavy water cooled and moderated power components reactor.	0 (60 thermal megawatts)	Under study by contract with AEC.	1956–60
Gas cooled, graphite moderated	40	do	1958–62
Boiling water with nuclear superheat	10 to 50	Proposal made to AEC	1958–62
Heavy water cooled and moderated	100 to 250	Under study by contract with AEC.	1958–63
Aqueous homogeneous solution	75 to 150		1959–65
Process heat reactor	0 (45 thermal megawatts)		1959–62
Fused salt-fueled	10		1959–64
Steam cooled, heavy water moderated.	10		1959–65
Intermediate energy neutron breeder.	10	Under study by Southwest Atomic Energy Associates.	1958–67
Water cooled, graphite moderated Hanford type.	300	Under study by contract with AEC.	1958–63
Pressurized water, enriched uranium fuel.	200		1959–64
Boiling water, enriched uranium fuel.	200		1960–65
Organic cooled reactor	50		1960–64
Liquid metal fueled reactor experiment.	0 (5 thermal megawatts)		1959–63
2 small 2d generation industrial plants.	15 to 40		1961–65
High temperature gas cooled, graphite or heavy water moderated.	200		1961–66
High temperature sodium cooled, graphite or D^2O moderated.	200		1961–66
Organic cooled reactor	200		1962–67
Sodium cooled fast or intermediate breeder.	200		1963–68
Liquid metal fueled reactor	50		1963–68

TABLE II.—*Status of power reactors underway or proposed* [1]

Project	Approximate electrical rating (megawatts)	Status	Approximate completion date
Boiling water, enriched uranium fuel.	180.0	Under construction by Commonwealth Edison Co.	1959
Pressurized water, enriched uranium fuel.	[2] 163.0	Under construction by Consolidated Edison Co. of New York, Inc.	1960
Do	134.0	Under construction by Yankee Atomic Electric Co.	1960
Boiling water, enriched uranium fuel.	[3] 16.5	Elk River Electric Cooperative and ACF; contract awarded by AEC under power demonstration program.	1961
Do	[4] 50.0	Northern States Power Co. & Associates; contract awarded by AEC under power demonstration program.	1962
Sodium cooled, fast breeder	100.0	Under construction by Power Reactor Development Co.	1960
Do	20.0	Under construction by Argonne National Laboratory.	1960
Sodium cooled, graphite moderated.	75.0	Under construction by AEC and Consumers Public Power District of Nebraska under power demonstration program.	1962
Sodium cooled, D_2O moderated.	10.0	Chugach Electric Association and Nuclear Development Corporation of America; research and development contract awarded by AEC under power demonstration program; letter of intent negotiated on construction.	1963
Organic cooled, organic moderated.	12.5	City of Piqua, Ohio, and Atomics International; [proposal accepted] by AEC under power demonstration program.	1961
Homogeneous aqueous slurry.	70–150.0	Pennsylvania Power & Light Co., Baltimore Gas & Electric Co., and Westinghouse Electric Corp.; research and development [proposal accepted] by AEC under power demonstration program.	1964
D_2O cooled, D_2O moderated, pressure tube.	17.0	Carolinas-Virginia Nuclear Power Association, Inc.; [proposal accepted] by AEC under power demonstration program.	1962
High temperature, gas cooled D_2O moderated, pressure tube.	50.0	East Central Nuclear Group and Florida West Coast Nuclear Group; [proposal accepted] by AEC under power demonstration program.	1963
Boiling water, enriched uranium fuel.	60.0	Announced February 1958 by Pacific Gas & Electric Co., and Bechtel.	1962

[1] Reactors in operation as of January 1958 omitted.
[2] Additional 112 electrical megawatts from oil fired superheater.
[3] Additional 5.5 electrical megawatts from coal fired superheater.
[4] Additional 16 electrical megawatts from oil fired superheater.

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